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Sex identification in Egyptian population using Multidetector Computed Tomography of the maxillary sinus

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ABSTRACT

Forensic anthropology involves the building of an antemortem profile of an individual from skeletal remains. This includes sex, race determination, and age and stature estimation. Because most bones that are conventionally used for sex determination are often recovered either in a fragmented or incomplete state, it has become necessary to use denser bones that are often recovered intact, eg, the maxillary sinus. The present work was performed to investigate the possibility of estimation of sex from some radiologic measurements among a known cross-section of Egyptian population. In this study, by the use of Multidetector Computed Tomography (MDCT) scan, eight maxillary sinus measurements were assessed in 96 living non-pathologic Egyptians comprising 48 males and 48 females aged 20–70 years referred to the Radiology Department. These were subjected to statistical analysis. Two variables showed significant differences: cephalo-caudal and size of the left maxillary sinus. The study concluded that the correct predictive accuracy was 70.8% in males and 62.5% in females. In conclusion, MDCT measurements of cephalo-caudal and size of the left maxillary sinuses are useful feature in gender determination in Egyptians.

1. Introduction

Post-mortem identification, a forensic procedure, is difficult to perform and it is obligatory in terms of the law and social norms. It has been reported that maxillary sinuses remain intact although the skull and other bones may be badly disfigured in victims who are incinerated and, therefore, that maxillary sinuses can be used for identification.[1]

Maxillary sinuses are two spaces, which are filled with air, located in the maxillary bone and there is a considerable variation in size and shape of the maxillary sinuses between the right and left sides. Their walls are thin. The apex of the sinuses can extend into the zygomatic process and can occupy the zygomatic bone. The floor formed by the alveolar process. The maxillary sinuses appear at the end of the second embryonic month, and they reach their mature sizes at the age of about 20 years, when the permanent teeth fully develop.[2]

Knowledge about human paranasal sinus pneumatization was initially developed by taking anatomical measurements, injecting different materials into cadavers or performing plain radiography[3].

Nowadays, the introduction of Multidetector Computed Tomography (MDCT) and magnetic resonance imaging (MRI), with thin axial sections and sagittal and coronal reformatted images as well as three-dimensional reconstructions, has allowed a more exact assessment of this structure. Furthermore, the application of morphometric procedures to these radiological images adds a new perspective to this analysis.[4]

The aim of this study was to evaluate the significance of MDCT measurements (the antero-posterior, transverse, cephalo-caudal and the size) of maxillary sinuses in identification of Egyptian populations and their gender.

2. Subjects and methods

Bones of preadolescent individuals are almost useless for sex determination because the secondary sexual characteristics don't appear until the bones are remodeled under the influence of estrogen and androgen at puberty.[5] For this reason our study therefore excluded samples below the age of 20 as Miller did in his study.

This study was based on a retrospective review of the paranasal sinuses MDCT scans in 96 cases (age ranged between 20 and 70 years old) who had MDCT (General Electric Prospeed 16 slice

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Table 1
The mean and standard deviation of both maxillary sinuses in Egyptian populations (in cm).

	Mean	SD
Right antero-posterior (RAP)	3.37	0.34
Left antero-posterior (LAP)	3.33	0.35
Right transverse (RT)	1.89	0.34
Left transverse (LT)	1.85	0.3
Right cephalo-caudal (RCC)	3.25	0.55
Left cephalo-caudal (LCC)	3.19	0.56
Right size (RS)	20.94	6.6
Left size (LS)	20.05	6.36

SD: standard deviation.

Helical CT, Milwaukee, US) of maxillary sinuses for various reasons between 1st January and 30th May in 2010. There was no history of sinus or ear disease in any of the subjects and clinical examination revealed no ear, nose or throat abnormality. Persons with congenitally absent sinuses were excluded, to have MDCT scans.

Of 96 adult patients, 48 (50%) were females and 48 (50%) were males. When MDCT was performed, the patients were in prone position and they did not have sedation or contrast medium.

To obtain the reformatted MDCT images, an MDCT HiSpeed Advantage (GE Medical Systems, Milwaukee, Wis., USA) with a high resolution bone algorithm, 15 cm field of view, 200 mA, 120 kV, scanning time of 1 s and slice thickness of 1 mm was used to obtain the axial images from the occlusal margin of the maxillary teeth to the inferior margin of the orbit. The axial images were reformatted to coronal and sagittal images and the reformatted cross-sectional images coronal and sagittal were used for the radiographic evaluation of the inferior wall of maxillary sinus and to observe the anterior and posterior limit of the sinus.

Using the MDCT data as Digital Imaging and Communications in Medicine (DICOM) files, three-dimensional reconstructed images of the maxillary sinuses were made using the V-works (version 3.0) program. The basic functions of V-works are as follows:

(1) The system can reconstruct three-dimensional models of human organs from various data sources, such as MDCT and MRI.
(2) Users can manipulate the models using a variety of interactive functions. For example, a user can browse a model using a mouse, navigate inside the model, or examine a cross-sectional view by registering and overlapping a 2D image on a three-dimensional model.
(3) Using the V-works simulation module, a user can create operation plans using a marking, measurement, cutting, and movement functions.

We performed various measurements on three-dimensional reconstructed images using V-works 3.0 program. The used measurement parameters were antero-posterior and transverse, measured from axial images, cephalo-caudal measured from coronal and sagittal reformatted images. All measures were taken between the widest points of the all of the sinuses, and size (multiplication of the previous three parameters) of maxillary sinuses on both sides.

Table 2
Comparison of the measurements of both maxillary sinuses of male versus female (in cm).

	Male		Female		*t*	*p*
	Mean	SD	Mean	SD		
Right antero-posterior (RAP)	3.36	0.31	3.39	0.36	0.28	0.78
Left antero-posterior (LAP)	3.334	0.35	3.329	0.35	0.05	0.96
Right transverse (RT)	1.89	0.37	1.88	0.31	0.05	0.96
Left transverse (LT)	1.91	0.27	1.78	0.32	1.51	0.14
Right cephalo-caudal (RCC)	3.373	0.54	3.13	0.55	1.55	0.13
Left cephalo-caudal (LCC)	3.371	0.50	3.01	0.63	2.23	0.03*
Right size (RS)	21.57	6.77	20.30	6.43	0.67	0.51
Left size (LS)	21.83	6.49	18.26	6.23	1.95	0.05*

SD: standard deviation; $P \leq 0.05$ = significant difference = *.

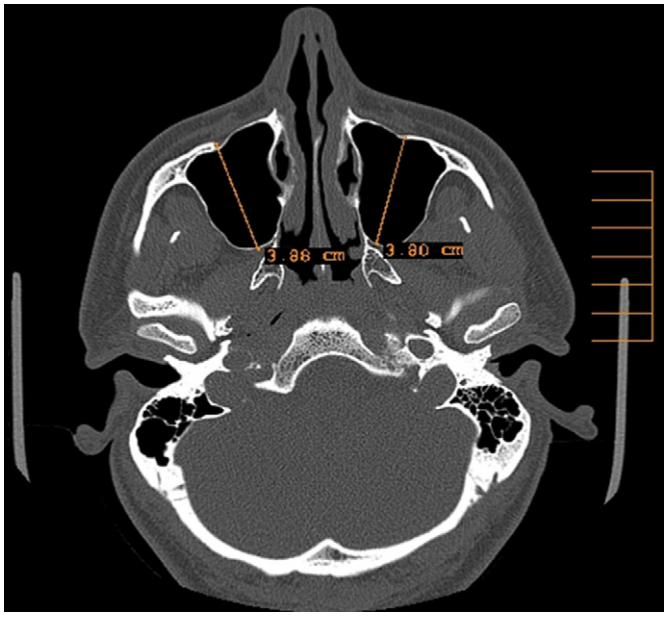

Fig. 1. Multidetector CT of both maxillary sinuses in 40 years old male, axial image, showing antero-posterior diameter of right and left maxillary sinuses.

2.1. Statistical studies

The mean and standard deviation of both maxillary sinuses measurements were done for all patients, and independent *t*-test was used to compare these values in the both sex. Discriminative analysis was used to detect gender by using the significant measurements. The statistical analyses were performed by using the SPSS 10 package program.

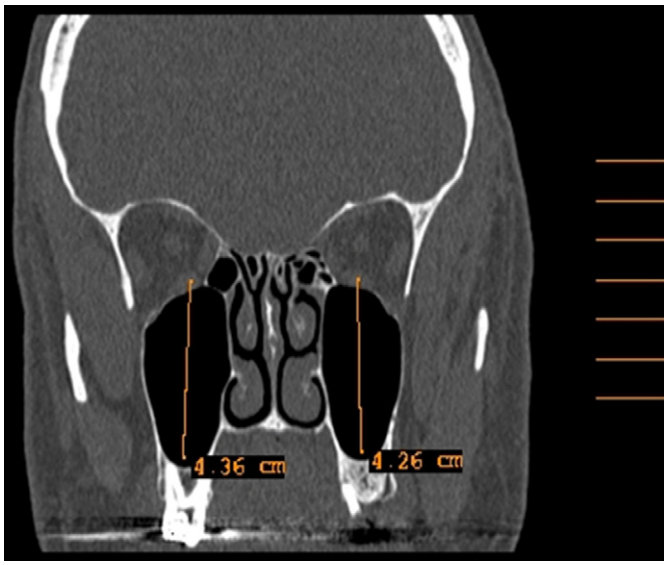

Fig. 2. Multidetector CT of both maxillary sinuses in 40 years old male, coronal reformatted image, showing cephalo-caudal diameter of right and left maxillary sinuses.

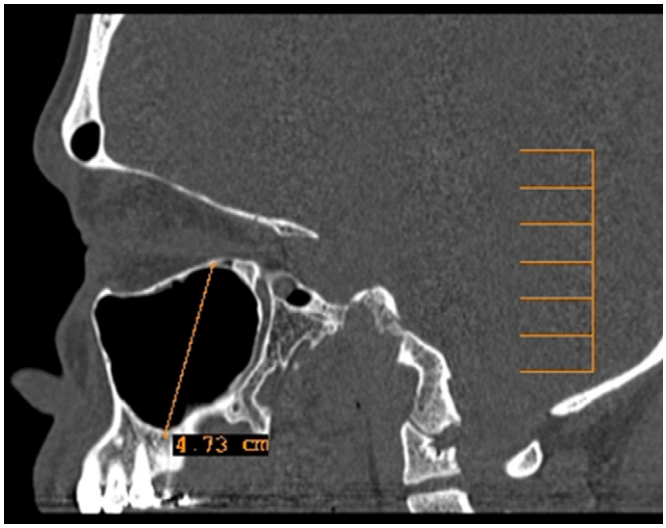

Fig. 3. Multidetector CT of both maxillary sinuses in 57 years old male, sagittal reformatted image, showing cephalo-caudal diameter of left maxillary sinus.

3. Results

Eight maxillary sinus measurements are assessed by MDCT scan in 96 individuals (48 males and 48 females) aged 20–70 years referred to the Radiology Department. Table 1 shows the mean antero-posterior, transverse, cephalo-caudal, and size of right and left maxillary sinuses with their standard deviations in centimeters (cm).

The gender distribution of the mean antero-posterior, transverse, cephalo-caudal, and size of maxillary sinuses with their standard deviations is shown in Table 2. The transverse, cephalo-caudal, and size of the maxillary sinuses of the female are found to be smaller than those of men. A significant difference is found in the cephalo-caudal and the size of the left sinuses between males and females (Table 2).

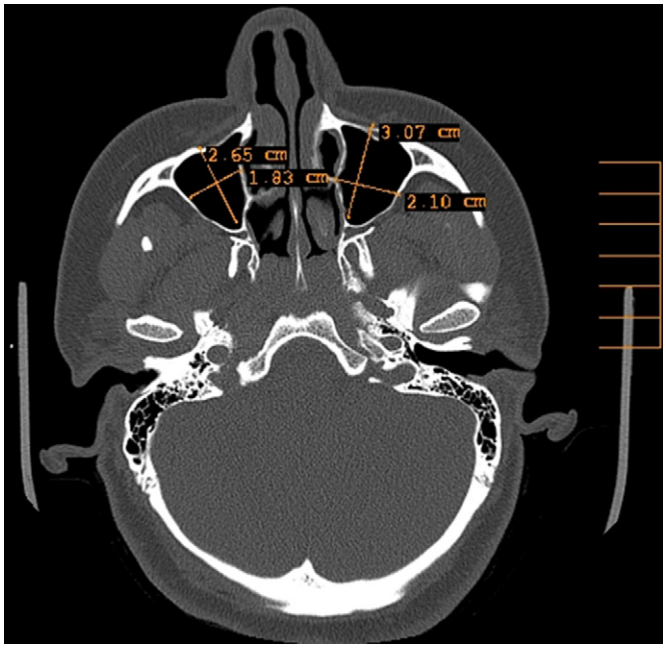

Fig. 4. Multidetector CT of both maxillary sinuses in 35 years old female, axial image, showing anteroposterior and transverse diameter of right and left maxillary sinuses.

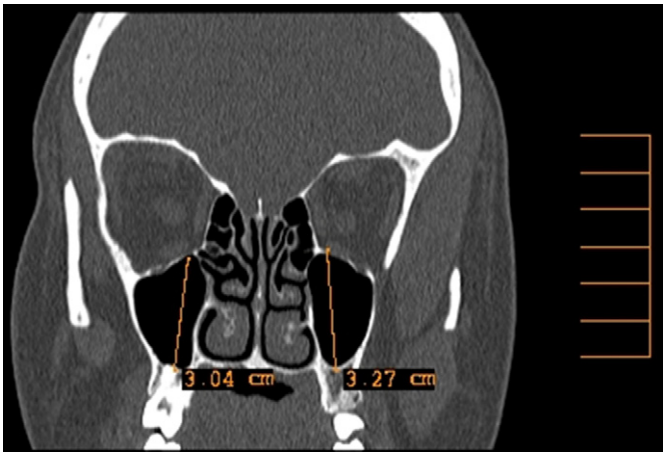

Fig. 5. Multidetector CT of both maxillary sinuses in 35 years old female, coronal reformatted image, showing cephalo-caudal diameter of right and left maxillary sinuses.

Figs 1–6– show MDCT of some males and females, with axial, coronal reformatted, and sagital reformatted images showing: antero-posterior, transverse, cephalo-caudal diameters of right and left maxillary sinuses.

A discriminant function was performed to the cephalo-caudal and size of left maxillary sinuses, which are significantly different in males versus females (Table 3).

The accuracy rate of the cephalo-caudal of the left maxillary sinus measurements was 66.7% in males and 50% in females, with a mean of 58.3% (Table 4).

The accuracy rate of the size of the left maxillary sinus measurements was 58.3% in males and 62.5% in females, with a mean of 60.4% (Table 5).

The accuracy rate of the both, cephalo-caudal and size of the left maxillary sinus measurements was 70.8% in males and 62.5% in females, with a mean of 66.7% (Table 6).

Discriminant function (df) = stand. coeff. × LCC + stand. Coeff. × LS.

df (males) = 0.757 × 3.370 + 0.305 × 21.833 = 9.21.

df (females) = 0.757 × 3.004 + 0.305 × 18.258 = 7.843.

Cut point = df (males) + df (females)/2 = 9.21 + 7.843 = 8.526.

So we can suspect the sex as follow: male if the df ≥ 8.526, and female if the df < 8.526.

Note: measurements of LCC and LS are in cm.

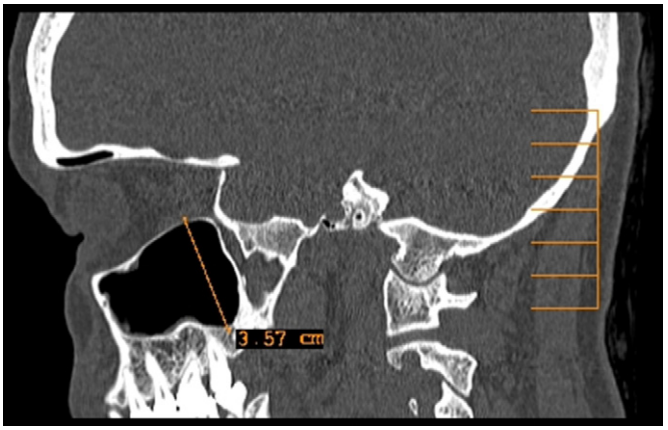

Fig. 6. Multidetector CT of both maxillary sinuses in 30 years old female, sagittal reformatted image, showing cephalo-caudal diameter of right maxillary sinus.

Table 3
Summary of Canonical Discriminant Functions of left cephalo-caudal and left size of maxillary sinuses.

	LCC	LS	LCC + LS
Eigen values	0.108	0.082	0.113
% of variance	100	100	100
Cumulative%	100	100	100
Canonical correlation	0.313	0.267	0.319
Wilks lambda	0.902	0.924	0.898
Chi-square	4.678	3.603	4.831
Significance	0.031	0.058	0.089
SC	1	1	LCC 0.757 LS 0.305

LCC: left cephalo-caudal.
LS: left size of maxillary sinuses.
SC: standardized coefficient.

4. Discussion

Identification from remains of human skeletons is an important forensic procedure. Today, MDCT scans are being performed for an expanding number of medical and dental reasons, thus ensuring their increasing availability in cases requiring personal identification. CT scanning equipment is available in most hospitals.[6]

Uthman et al., 2011,[7] concluded that reconstructed CT image can provide valuable measurements for maxillary sinuses and could be used for sexing when other methods of sexing are not conclusive.

In a study done on 13 Egyptian Human Mummies, reported that CT, in particular helical CT, followed by multiplanar and three-dimensional (3D) reconstructions, has improved both the quality and the quantity of available information of specimens not directly visible under the wrappings. The use of CT is increasingly important, especially among anthropologists and paleopathologists.[8]

In this study, by the use of MDCT scans, eight maxillary sinus measurements were assessed and resulted in: the Egyptian measurements of the maxillary sinus are described as 33.5 mm in antero-posterior diameter, 18.7 mm in transverse diameter, and 32.2 in cephalo-caudal diameter.

In Gray's Anatomy, the overall measurements of the maxillary sinus are described as 32 mm in anterior-posterior diameter, 25 mm in mediolateral diameter (transverse), and 35 mm in superior-inferior diameter (cephalo-caudal).[9]

As Koreans, Egyptian antero-posterior is greater than that reported in Gray's Anatomy. But conversely to Koreans, The transverse and cephalo-caudal of Egyptian maxillaries are lesser than that reported in Gray's Anatomy.[10]

Gender determination is really important for identification. In our study two variables showed significant differences between males and females: cephalo-caudal and size of the left maxillary sinus. The study concluded that the correct predictive accuracy was 70.8% in males and 62.5% in females.

By the use of spiral CT scan six mandibular measurements were assessed in modern Egyptian population. Many variables showed significant differences between males and females and included: bicondylar breadth, gonial angle and minimum ramus breadth. The overall predictive accuracy was 83.9%.[11]

Some radiologic measurements among a known cross-section of Egyptian population revealed that one function associating 2 parameters (length and midshaft) of the third metatarsal bone obtained the highest value of correct sex determination with rate of 100% accuracy.[12]

In the current study, transverse, cephalo-caudal, and size of the maxillary sinuses of the female were found to be smaller than those of men. Fernandes, 2004[13], reported that the maxillary sinuses are larger in males than in females in Europe and these results as we found. But in Zululand, the maxillary sinuses are narrower in males than in females, and this may be explained as the maxillary sinus has a racial role or the ages of the specimens were larger.

In our research, the antero-posterior and cephalo-caudal of the right maxillary sinus are larger than those of the left sinus in both genders, which are against.[14]

We found that the measurements of the right maxillary sinus are larger than those of the left sinus in females, and these results were accepted in Turkey by Teke et al., 2007.[15]

Table 4
Gender determination from measurements of the cephalo-caudal of the left Maxillary sinus.

Group			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	32	16	48
		Female	24	24	48
	%	Male	66.7	33.3	96
		Female	50	50	96

Table 5
Gender determination from measurements of the size of the left Maxillary sinus.

Group			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	28	20	48
		Female	18	30	48
	%	Male	58.3	41.7	96
		Female	37.5	62.5	96

Table 6
Gender determination from measurements of the both (cephalo-caudal and size) of the left Maxillary sinus.

Group			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	34	14	48
		Female	18	30	48
	%	Male	70.8	29.2	96
		Female	37.5	62.5	96

5. Conclusion

Cephalo-caudal and size of the left maxillary sinuses by MDCT may be useful to support gender determination in Egyptians (accuracy rate 70.8% for males). However, further studies on gender determination from the maxillary sinuses are needed.

Conflict of interest

All authors disclose no financial or personal relationships with other people or organisations that could inappropriately influence (bias) their work. Either potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding.

Ethical approval

Not required.

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